SPEED OF CEPHENEMYIA

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The following brief explanatory data are offered on the speed, at 12,000 to 13,000-foot levels, of male deer botflies of the tentatively determined species *Cephenemyia pratti*, known only from New Mexico, Texas, Chihuahua and California, which speed has been challenged by Dr. Irving Langmuir in *Science* of March 11, 1938.

The challenger, judging fly metabolism and mechanics by man metabolism and mechanics and comparing the fly with a zeppelin (which, being lighter than air, has no bearing on the problem), not realizing that the fly's mechanism is vastly more efficient in doing work for itself than the man's, nor that it works on stored energy instead of constant food consumption, and assigning wrong values for the fly in a ballistics equation, came to the extraordinary conclusion that 25 m.p.h. is a fair estimate of *Cephenemyia* speed!

Since the editor of *Science* has twice declined to publish a reply to the challenge, it must be stated here that the latter embraced the following assertions: That the fly has a very flat head, so that $\frac{1}{4}$ is too low a value for f in the ballistics equation; that $\frac{1}{2}$ is a lower than actual value for d and 1 is the value for p (here substituted for Greek letter ρ) in same equation; that with these values the equation gives 100 grams of drag at 818 m.p.h.; that 8 lbs. per square inch is the wind pressure on the fly's head at same speed, probably enough to crush the fly; that power consumption at same speed would be 370 watts per second; that the fly is 1 cm. in length and $\frac{1}{2}$ cm. in diameter; that a whirling piece of solder of same dimensions becomes invisible at 64 m.p.h.; that impact of fly on collision at 800 m.p.h. would be 310 lbs.; that fly must consume $1\frac{1}{2}$ times its own weight of food per second to maintain speed of 818 m.p.h. Now for the facts in the case.

In properly conceived flight position, the fly is streamlined to the limit, its movable head inclined slightly downward and its extended legs lying close beneath the abdomen. In this position it shows a total length of fully 16 mm. and a diameter of $5\frac{1}{3}$ mm. at nearly

$\frac{1}{3}$ the length, more than the posterior $\frac{2}{3}$ tapering to the leg tips. Its weight is about $\frac{1}{5}$ of a gram.

In the equation, $R = pd^2v^2f$ (R is drag; p, atmospheric pressure or air density; d, diameter; v, velocity; f, shape in relation to velocity), it should take 1/60 as value of f, 1/7 as value of d^2, 490,000 to 657,700 as value of v^2 at 700 to 800 m.p.h., 7/11 as value of p at the high levels where it attains top speed. It is to be noted that the complete streamlining of the fly reduces drag 50 per cent on both d^2 and f, making d^2 1/7 and f 1/60; otherwise d^2 would be 2/7 and f 1/30. Power required at 800 m.p.h. is 1.95 times that required at 700 m.p.h.

On these values, the fly's drag at 800 m.p.h. would be 0.997 grams, requiring scarcely 3.63 watts power per second. But it now seems probable, in the light of aeronautic experiments during the past decade, that the fly does not much exceed the speed of sound. The writer's original announcement, made 12 years ago (*Scientific Monthly* of April, 1926), closed with the admitted possibility that the actual speed might be only $\frac{1}{2}$ the estimated. This is not an effort to hedge, for it was stated plainly at the time and was made in view of the inevitable exigencies of the most careful estimates. The actual speed must be determined by a high-speed camera taking 1,000 to 4,000 exposures per second. It will certainly fall between 409 and 818 m.p.h.

On the same values, at 700 m.p.h., we have for the equation: $R = 7/11 \times 1/7 \times 490000/1 \times 1/60 = 742.42$ dynes or 0.74242 gram drag. As we figure 1 watt power for 10,000 cm. gms. of drag per second or 3.13 watts for 31,300 cm. gms. per second at 700 m.p.h. less 20 per cent reduction of power to match the 20 per cent reduced drag due to weight at high velocity, the result of which drag reduction is embraced in the equation, we have 2.504 watts required per gram of drag or 1.859 watts for 0.74242 gram of drag, which is 1/402 h-p. Thus 402 flies deliver 1 h-p. per second at 700 m.p.h. This is checked by the computation that 402 flies overcome a total resistance of 298 grams at the velocity of 31,300 cm. per second, which is slightly over 1 h-p.

While the above figures are the most accurate that can be computed with our present knowledge of insect metabolism and mechanics, they must be verified by future research on this practically unknown subject. As an example, a flea can jump over 200 times its height and live 18 months without food or water. What is known regarding the mechanics of the flea and its astonishing metabolism? When a man can jump twice as high as the Washington Monument and live a year and a half without a bite or a drink, it will be time to judge insect metabolism and mechanics by man metabolism and mechanics. The exoskeletal mechanics and cold-blooded metabolism of the insect with its stored energy, open blood system and extensively ramifying respiratory-airsac system are strongly contrasted with the endoskeletal mechanics and warm-blooded metabolism of man with his continual food consumption, closed blood system and pulmonary respiration, greatly to the advantage of the insect for doing work.

The fly takes no food and its power supply constitutes its marvelous mechanical secret deserving the most thorough investigation in the interests of aviation. Outside of oxygen assimilated in respiration, its entire power supply lies in its fatbody and was acquired during its maggot stages. Wimperis stated last year in his presidential address before the Royal Aeronautical Society that if we can suppress everything but laminar drag or if some entirely new motor is invented of much greater power per pound of weight, it may be possible to attain higher speeds than about 600 m.p.h. *Cephenemyia* has the second of these alternative requirements; namely, motor of far greater power per unit of weight!

The fly is of course totally invisible at top speed and leaves a visible blur in the air only when it suddenly decelerates to veer off and thus avoid collision with the observer. It requires very superior eyesight to sense the blur, which however becomes a disappearing dot against the sky in a straightaway course. A whirling object can not apply at all in this case. The fly probably decelerates to 100 m.p.h. at the blurred section of its course. The fact that the oncoming fly appears suddenly without previous sound warning implies a speed approximating that of sound. The writer stated in 1928 (*West Coast Leader* of March 27) that the fly is audible on approach, but he mistook the close-up sound for the sound of approach.

The fly never collides with any object, due to its power of super-rapid deceleration, which implies the same rate of acceleration on passing the object. If it should collide, its decelerated speed would result in very low impact. But a direct hit at 800 m.p.h. would develop an impact of only 10.09 lbs., since the fly would come to rest in 1.6 cm. distance, which gives 19.5 fly-impact units per ft. lb. At 700 m.p.h., direct hit impact would be 8.829 lbs. In any case the fly would decelerate to a fraction of the above impacts. It is evident that the fly has developed its extraordinarily rapid deceleration of necessity, as protection against collisions at its great speed. Less rapidity of deceleration would result in collision and the death of the fly. In millions of flight years the fly has perfected both its streamlining and its flight mechanics.

Dr. Langmuir's allusion to his recollections of deerflies shows that he confused the common bloodsucking tabanid fly *Chrysops,* called deerfly in the eastern United States, with *Cephenemyia.* He can scarcely have known the eastern *Cephenemyia phobifer,* which is rarely met with. *Chrysops* goes 25 m.p.h. but *Cephenemyia* goes more than 25 times 25 m.p.h.!

In conclusion, *Cephenemyia* can scarcely fail to reach 650 to 750 m.p.h. at top speed, which is by far the swiftest observed flight of all organisms and may with entire confidence be entered as a world record. The writer does not yet regard 800 m.p.h. as impossible but merely as improbable. Both the scientific and the lay press may therefore take note that *Cephenemyia* is not debunked by Dr. Langmuir's conscientiously advanced but grossly inaccurate data. It is the present speed champion of the world. Only its close ally, *Portschinskia* of Asia, may possibly compete with it. But the airplane should eventually excel both in speed.[1]

[1] A detailed treatment of the mechanics of this subject will appear in Part XII of the *Manual of Myiology,* comparing the fly and the flea with both man and each other and the fly with both projectiles and airplanes.